The XXVII International Scientific Conference of Young Scientists and Specialists (AYSS-2023)

Contribution ID: **1444** Type: **Poster**

Small-angle X-ray scattering and Raman spectroscopy as methods for assessing the effect of dehydrothermal crosslinking of keratoplasty material

Monday 30 October 2023 19:00 (5 minutes)

The problem of creating transplants to replace and stimulate the regeneration of damaged organs or tissues in medicine is of critical importance. In particular, there are various pathologies of the cornea of the eye (injuries, degenerative processes) that cause irreversible changes and lead to blindness. The mammalian corneal stroma can serve as a potential material for creating an artificial cornea. However, when creating such implants, problems of immunogenicity, biocompatibility and long-term preservation of optical transparency after implantation arise. Despite the large number of artificial corneas offered, the search for the optimal composition of the corneal implant and methods of its processing remains an urgent task.

It is known that the basis of the corneal stroma is type I collagen. One of the options for reducing the ability of collagen to hydrate is collagen crosslinking (the formation of cross-links between polypeptide chains). An early study of corneal grafts ("Corneoplast") showed that dehydrothermal crosslinking (DTC) of the corneal stroma can be used to increase the resistance of grafts to hydration without critical loss of optical and strength properties. In modern corneal surgery, materials with similar properties are not yet used.

The aim of this work was to assess the effect of DTC of stromal corneal grafts based on the material for keratoplasty Corneoplast at temperatures of 60, 100, 140℃ on their physical, structural and biological properties. The study of the graft structure was carried out by the method of small-angle X-ray scattering (SAXS), Raman spectroscopy (RS) was used to study the degree/level of hydration of the material.

As a result of the study, data were obtained on the structure and properties of the grafts under study, on the basis of which it can be concluded about the ability of grafts to hydrate/dehydrate and about the storage conditions of grafts for medical purposes. In particular, the ability of grafts to hydrate/dehydrate in water and in a phosphate-salt buffer (pH=7.4) and related changes in structural parameters such as the D-spacing, the distance between the triple helices of collagen, the distance between amino acid residues, the contributions of "free"and collagen-bound water in the grafts were evaluated. It was also found that small-angle X-ray scattering and Raman spectroscopy are reliable methods of quality control of materials for keratoplasty. According to our research, it is possible to make changes to the protocol to improve the quality of preparation of grafts for keratoplasty.

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Session Classification: In-person poster session & welcome drinks

Track Classification: Life Science